WHAT IS CLAIMED IS:

1. An electromagnetic actuator, comprising:

a stator assembly having an inner surface that defines an opening, the stator assembly comprising:

a coiled conductor disposed near the inner surface of the stator assembly, wherein the coiled conductor is adapted to generate a first magnetic field when current is applied;

a center pole formed of a material having high magnetic permeability and having a longitudinal axis; and

an armature assembly at least partially disposed within the stator assembly opening, the armature assembly comprising:

a permanent magnet, wherein the armature assembly moves in a direction parallel to the longitudinal axis of the center pole when current is applied to the coiled conductor assembly.

2. The electromagnetic actuator of claim 1 wherein the magnet is radially magnetized.

3. The electromagnetic actuator of claim 1 wherein the center pole comprises:

a plurality of segments, each formed of material having high magnetic permeability.

4. The electromagnetic actuator of claim 1, wherein the stator assembly further comprises a plurality of adjacent coiled conductors.

5. The electromagnetic actuator of claim 4, wherein the armature assembly further comprises:

a plurality of adjacent radially magnetized permanent magnets.

6. The electromagnetic actuator of claim 5 wherein adjacent permanent magnets have opposite polarity.

7. The electromagnetic actuator of claim 4 wherein adjacent coils are configured to generate magnetic fields having opposite polarity.

8. The electromagnetic actuator of claim 4 wherein the plurality of coils are connected in series.

9. The electromagnetic actuator of claim 7 wherein adjacent coils are wound in opposite directions.

10. The electromagnetic actuator of claim 7 wherein adjacent coils are wound in the same direction and are configured to receive current with opposite relative polarity.

11. The electromagnetic actuator of claim 1 wherein the stator assembly further comprises one or more back iron members formed of a material having high magnetic permeability.

12. The electromagnetic actuator of claim 1 wherein the permanent magnet is ring-shaped and defines longitudinal axis that is parallel with the longitudinal axis of the center pole.

13. The electromagnetic actuator of claim 12 wherein the longitudinal axis of the permanent magnet is coaxial with the longitudinal axis of the center pole.

14. The electromagnetic actuator of claim 1 wherein the stator assembly defines a longitudinal axis that is parallel l to the longitudinal axis of the center pole.

15. The electromagnetic actuator of claim1 where in the longitudinal axis of the stator assembly is coaxial with the longitudinal axis of the center pole.

16. The electromagnetic actuator of claim 12 wherein the permanent magnet is radially magnetized.

17. The electromagnetic actuator of claim 12 wherein the magnet has one or more discontinuities such that the dominant eddy current path is interrupted.

18. The electromagnetic actuator of claim 12 wherein the permanent magnet comprises a plurality of arc-shaped segments.

19. The electromagnetic actuator of claim 1 wherein the armature assembly further comprises a valve stem adapted to open or close a valve when current is applied to the coiled conductor.

20. The electromagnetic actuator of claim 19, wherein the center pole defines a channel and the valve stem is at least partially disposed within the channel.

21. The electromagnetic actuator of claim 19, wherein the armature assembly further comprises:

a means for coupling the valve stem to the remainder of the armature assembly.

22. The electromagnetic actuator of claim 19, wherein the valve stem comprises:

a first end having a ball-shaped tip;

and wherein the armature assembly further comprises:

a ball joint assembly comprising a ball cage configured to receive the ball-shaped tip of the valve stem such that the valve stem is coupled to the ball joint assembly in at least a direction parallel to the longitudinal axis of the center pole.

23. The electromagnetic actuator of claim 22 wherein the valve stem is coupled such that the valve stem has freedom of movement in directions perpendicular to the longitudinal axis of the center pole.

24. The electromagnetic actuator of claim 22 wherein the valve stem is coupled to the ball joint assembly such that the valve stem has freedom of to rotate around the longitudinal axis of the center pole.

25. The electromagnetic actuator of claim 5 wherein the armature assembly further comprises one or more spacers disposed between each of the permanent magnets.

26. The electromagnetic actuator of claim 25 wherein the magnets and spacers are split in the axial direction.

27. The electromagnetic actuator of claim 1 wherein at least a portion of the inner surface of the stator assembly is coated with a dielectric material.

28. The electromagnetic actuator of claim 1 wherein an outer surface of the center pole acts as a bearing surface for the armature assembly.

29. The electromagnetic actuator of claim 28 wherein the outer surface of the center pole is coated with a low-friction coating.

30. The electromagnetic actuator of claim 1 wherein the axial height of the magnet is less than the axial height of the coiled conductor.

31. The electromagnetic actuator of claim 1 wherein the axial height of the magnet is greater than the axial height of the coiled conductor.

32. The electromagnetic actuator of claim 1 wherein the center pole is formed of a paramagnetic material.

33. The electromagnetic actuator of claim1 wherein the force of the armature as a function of displacement of the armature relative to the stator assembly is substantially constant over an intended range of excursion.

34. The electromagnetic actuator of claim 1 wherein the detent force profile of the actuator as a function of displacement of the armature relative to the stator assembly is substantially zero over an intended excursion range of displacement.

35. The electromagnetic actuator of claim 1 wherein the center pole is at least partially formed of ferromagnetic material.

36. The electromagnetic actuator of claim 1 further comprising:

a cooling jacket disposed at least partially around the stator assembly, the cooling jacket defining one or more channels configured to circulate cooling fluid.

37. The electromagnetic actuator of claim 1 wherein the center pole defines one or more channels configured to circulate cooling fluid.

38. A computer-implemented method for controlling an electromagnetic valve actuator having a stator that defines a longitudinal axis and an armature disposed within the stator, the method comprising:

receiving information about velocity and position of the valve;

applying a control signal to the actuator by selectively activating a velocity feedback loop and a position servo feedback loop to position the valve to a desired position.

39. The method of claim 38 wherein the velocity feedback loop reduces the valve velocity.

40. The method of claim 38 wherein the desired position is where the valve is fully opened.

41. The method of claim 38 wherein the desired position is where the valve is fully closed.

42. The method of claim 38 wherein electromagnetic actuator is the actuator in claim 1.

43. The method of claim 38 wherein the actuator has a predetermined profile of detent force versus actuator displacement, the method further comprising:

activating the velocity feedback loop to compensate for the detent force at a given armature displacement.

44. An electromagnetic valve actuation system, comprising:

the electromagnetic actuator of claim 1 configured to open and close a valve;

a controller configured to receive information about one or more operating states of the valve and apply a control signal to the coil to generate a magnetic field that causes the armature assembly to move relative to the longitudinal axis of the center pole, wherein the control signal is based on the information about one or more operating states of the valve.

45. The electromagnetic valve actuator assembly of claim 44 wherein the one or more operating states comprises valve velocity.

46. The electromagnetic valve actuator assembly of claim 44 wherein the one or more operating states comprise valve position.

47. The electromagnetic valve actuator assembly of claim 44 wherein the controller receives information about both the velocity and position of the valve and selectively applies a velocity feedback control and a position feedback control to position the valve.

48. An internal combustion engine comprising:

a cylinder that defines a chamber;

a valve adapted to control the flow of a liquid or a gas into or out of the chamber; and

an electromagnetic actuator coupled to the valve, the actuator comprising:

a stator assembly having an inner surface that defines an opening, the stator assembly comprising:

a coiled conductor disposed near the inner surface of the stator assembly, wherein the coiled conductor is adapted to generate a first magnetic field when current is applied;

a center pole formed of a material having high magnetic permeability and having a longitudinal axis; and

an armature assembly at least partially disposed within the stator assembly opening, the armature assembly comprising:

a permanent magnet, wherein the armature assembly moves to open or close the valve when current is applied to the coiled conductor assembly.

49. The internal combustion engine of claim 48 further comprising:

a controller configured to receive information about one or more operating states of the valve and apply a control signal to the coil to generate a magnetic field that causes the armature assembly to move relative to the longitudinal axis of the center pole, wherein the control signal is based on the information about one or more operating states of the valve.

50. The internal combustion engine of claim 49 wherein the one or more operating states comprises valve velocity.

51. The internal combustion engine of claim 49 wherein the one or more operating states comprise valve position.

52. The internal combustion engine of claim 49 wherein the controller receives information about both the velocity and position of the valve and selectively applies a velocity feedback control and a position feedback control to position the valve.

53. The internal combustion engine of claim 48 further comprising:

a cooling circuit comprising:

heat exchanger; and

a pump configured to circulate cooling fluid between the electromagnetic actuator and the heat exchanger.

54. The internal combustion engine of claim 53 wherein the electromagnetic actuator further comprises:

a cooling jacket disposed at least partially around the stator assembly, the cooling jacket including one or more channels that circulate cooling fluid between the electromagnetic actuator and the heat exchanger.

55. The internal combustion engine of claim 53 wherein the center pole further includes one or more channels that circulate cooling fluid between the electromagnetic actuator and the heat exchanger.